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Some biological parameters of the Striped red mullet (*Mullus surmuletus* L.) from the Bay of Edremit (Northern Aegean Sea, Turkey)

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Growth, sex ratio, and reproduction of striped red mullet (Mullus surmuletus L.) *were determined from 520 specimens collected in the northwestern Aegean coast of Turkey from September 2009 to July 2010. Total length ranged from 7.7 to 17.0 cm while weight varied between 3.50 and 58.9 g. According to the length-weight relationship, positive allometry was confirmed for both sexes. The sex ratio was skewed in favour of males (1:1.73). The monthly values of gonadosomatic index (GSI) of females indicated that spawning occurred mainly between April and September with a peak in July. Values of Condition factor (CF) and Hepatosomatic index (HSI) varied between 0.71-1.57 and 0.10-1.43, respectively.*

Key words: *Mullus surmuletus,* Edremit Bay, length-weight relationship, sex-ratio, gonadosomatic index

INTRODUCTION

The Striped red mullet, *Mullus surmuletus* occurs along the coast of Europe from the North Sea to Gibraltar, along the northern part of West Africa to Dakar, and in the Mediterranean and Black Seas (HUREAU, 1986).The striped mullet is one of the important small-sized demersal species in Turkish waters, widely caught as 15.681 tones in Edremit Bay in the years of 1995 to 1999 (KARA & GURBET, 1999). Namely, the mean annual catch of red mullet and striped mullet increased from 817 tons to 1978 tons in 2008 (KOCATAS & BILECIK, 1992; TUIK, 2008).

In Europe, MORALES-NIN (1992), VASSIPOULOU & PAPACONSTANTINOU (1992), CAMPILLO (1992), RENONES *et al*. (1995), PAJUELO *et al*. (1997) investigated biological parameters of striped red mullet population in Majorca, Greek Waters, France, and Canary Islands, respectively. MORATO *et al*. (2001), ABDALLAH (2002), MOUTOPOULOS & STERGIO (2002) estimated length-weight relationships of striped mullet populations in North Atlantic, Egyptian Waters, and the Aegean Sea, respectively. While N'DA & DENIEL (2005) reported that *M. surmuletus* spawns in May and June on the southern coast of Brittany, RENONES *et al*. (1995) pointed out that females spawn around

spring along the continental shelf off the Island of Majorca.

As to Turkish Seas, there are few published studies concerning various aspects of *M. surmuletus* biology, ecology, and fisheries (reproduction, age and growth) (OZAYDIN & TASKAVAK, 2007; GOKCE *et al*., 2007; ILHAN *et al*., 2009). However, biological studies of this species in Edremit Bay, northern Aegean Sea are very limited.

The aim of this paper was to examine the population structure of *M. surmuletus* in order to provide better knowledge and to compare the data with the relevant studies and thus help in the protection of the striped mullet stock in the Edremit Bay, northern Aegean Sea.

MATERIAL AND METHODS

A total of 520 specimens of *M. surmuletus* were obtained from commercial fisheries at monthly intervals, between September 2008 and July 2009 from Kücükkuyu in Edremit Bay, northern Aegean Sea (26º57'-26º34'E and 39º17'-39º34' N) (Fig. 1). This area is characterized by important fisheries and tourist centers.

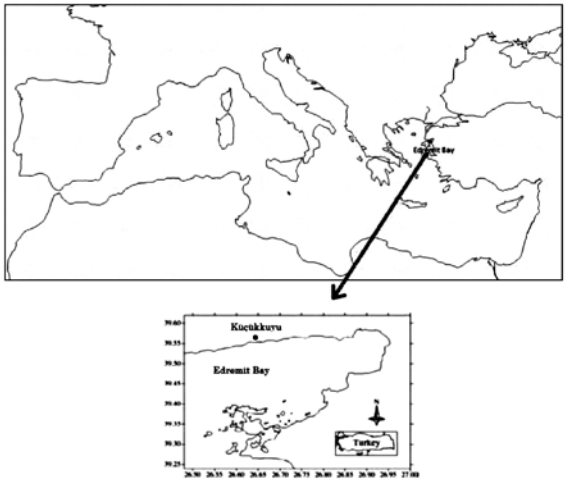

Fig. 1. Map of the studied area

Specimens were subjected to biological analysis. Each fish was measured to the nearest 0.1 cm of total length (TL) and weighed to the nearest 0.1 g. The length-weight relationship was calculated by applying an exponential regression equation $W=aL^b$where, W is the weight (g), L is the total lenght (cm), and a and b are constants.

During the reproductive cycle and physiological condition were determined monthly from the hepatosomatic index (HSI%) and the condition factor (CF). Condition factor (CF) was calculated as $CF=(W/L^3)*100$ for each sex to assess the maturity, condition of specimens and an overall measurement of being strong and healthy of the fish (AVSAR, 2005). Hepatosomatic index [(HSI=(liver weight/gutted weight)×100)]: this estimates the relative size of the liver to body weight (GARCIA-DIAZ *et al.,* 2006)

For the description of the sexual cycle of *M. surmuletus*, the maturation scale developed for this species was adopted (HOLDEN & RAITT, 1974), based on the macroscopic aspect and relative dimensions of the gonads. The overall sex ratio was determined. Deviations from 1:1 hypothesis were tested statistically by chi-squared analyses (SOKAL & ROHLF, 1981). The spawning period of *M. surmuletus* was determined by analyzing the monthly evolution of the gonado-somatic index (GSI), according to the expression: GSI=[Gonad weight/(Body weight-gonad weight)*100] (AVSAR, 2005)

RESULTS

Length and weight frequency distribution

The total length ranged from 7.7 to 17.0 cm, with lengths of 10 cm being the most dominant in the sample (n=520) (Fig. 2).

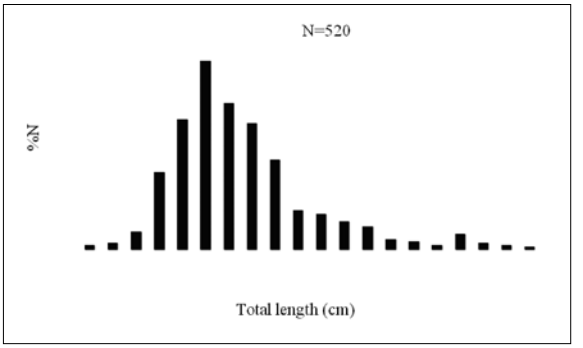

Fig. 2. Total length frequency distribution of all Mullus surmuletus specimens from Edremit Bay between the years 2008-2009

Sex ratio

Sex ratio was summarized in Fig. 3. There were about 63.46% males and 36.54% females, and differences between sexes according to age were statistically significant (χ^2=0.129, P<0.05). The sex ratio (F:M) was 1.00:1.73.

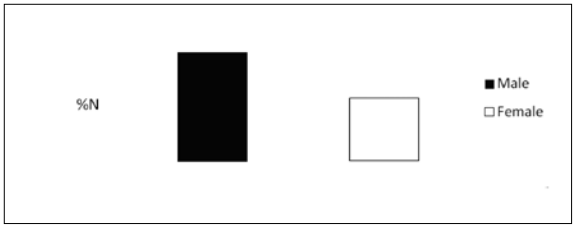

Fig. 3. Sex ratio of all Mullus surmuletus specimens from Edremit Bay between the years 2008- 2009

Length-weight relationship

Length–weight relationships were calculated by using the data of 520 *M. surmuletus* specimens. The length-weight relationship was estimated to $W=0.0042L^{3.36}$ (R^2=0.94). The relationship was allometrically positive, since the value of 3.38 showed a statistically significant difference from the value 3.0 (t-test, P<0.05)

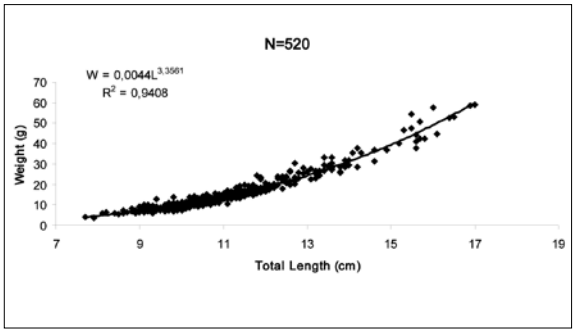

Fig. 4. Length- weight relationship of all Mullus surmuletus specimens from Edremit Bay between the years 2008-2009

Condition Factor

The seasonal variations in the condition coefficients were determined for all the individuals (Fig. 5). In general, monthly conditions exhibited a similar pattern for all individuals, showing a peak in September.

Gonad development and spawning period

Gonad development was followed using the GSI. Monthly changes are plotted in Fig. 5. Spawning occurred between April and October, showing a peak in July.

Hepatosomatic index (HSI%)

In general, monthly HSI values exhibited a similar pattern for both sexes, showing a peak in February (Fig. 5).

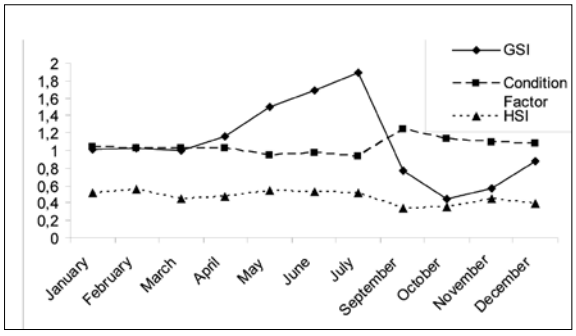

Fig. 5. The comparisons of monthly HSI, CF, and GSI values of all Mullus surmuletus specimens from Edremit Bay between the years 2008-2009

DISCUSSION

In striped red mullet population in Edremit Bay, the population consisted of 63.46% males and 36.54% females, and the sex ratio of 1.00:1.73 (F:M), estimated to be significantly different from 1:1 (t-test). Although the sex ratio in most of the species was close to 1, this may vary from species to species, differing from one population to another of the same species, and may vary year after year within the same population (NIKOLSKY, 1980).

Maximum lengths recorded prior to our study were 9.7-32.0 cm (Tab.1). This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex, gear selectivity, gonadal development, and geographical variations (RICKER, 1975; TIRASIN, 1993).

Length-weight relationship is very useful for fisheries research as it allow the easy conversion of length in weight and vice versa. The

Table 1. Parameters of the length-weight relationship (a, b) of Mullus surmuletus in this study and previous studies (-indicates absence of data)

Investigators	a	b	$L_{min-max}$ (cm)	Length	N	R^2	Area
Campillo (1992)	0.0182	3.000	-	-	-	-	Lion Bay, France
Djabali *et al.*, (1993)	0.0067	3.000	-	-	-	-	İyon Sea, İtaly
Djabali *et al.*, (1993)	0.0093	3.000	-	-	-	-	Sicily, İtaly
Papaconstantinou *et al.* (1993)	0.0150	3.037	7.4-24.4	FL	390	0.970	Aegean Sea, Greece
Papaconstantinou *et al.* (1994)	0.0116	3.149	7.0-24.0	FL	292	0.980	Aegean Sea, Greece
Petrakis and Stergiou, (1995)	0.0124	3.140	10.1-20.1	FL	307	0.985	Evvoikos, Greece
Reňones *et al.* (1995)	0.0091	3.120	10.0-32.0	TL	3541	0.980	MajorcaIslands(N.W.Med.)
Dulčić and Kraljević, (1996)	0.0010	3.512	15.4-30.9	TL	127	0.941	East Adriatic, Croatia
Merella *et al.*, (1997)	0.0082	3.090	10.3- 16.7	TL	13	0.993	Balear Islands, Spain
Pajuelo *et al.* (1997)	0.0074	3.1826	12-33	TL	-	-	Canary Islands
Labropoulou *et al.*, 1997			62-230 mm	TL	446		Eastern Mediterranean
Abdallah (2002)	0.0110	3.030	5.4- 20.8	TL	122	0.855	Alexandria coasts, Egypt
Moutopoulos, Stergiou (2002)	0.0140	2.954	13.8-32.0	TL	257	-	Aegean Sea
Koutrakis and Tsikliras, (2003)	0.0045	3.510	4.4-9.7	TL	48	0.994	Aegean Sea (North-East)
Vale *et al.*, (2003)	0.0097	3.075	7.7- 25.4	SL	146	0.998	Spain (East coasts)
Filipović and Raspor (2003)			9 4 - 2 3 6 (mm)				
Çicek *et al.*, (2006)	0.0082	3.110	5.5-22.2	TL	145	0.984	Babadilli Bay (Mediterranean)
Dulčić and Glamuzina, (2006)	0.0039	3.367	12.5-28.5	TL	47	0.963	East Adriatic, Croatia
Karakulak *et al.*, (2006)	0.0069	3.192	10.9-29.9	TL	601	0.976	Aegean Sea (North)
Özaydın *et al.*, (2007)	0.0106	3.202	7.4-21.9	FL	117	0.990	Izmir Bay
Gökçe *et al.* (2007)	0.0131	2.97	7.3-18.6	TL	38	0.980	Aegean Sea
Mehanna (2009)	0.0104	3.0617	-	-	-	0.979	Egypt
İlhan *et al.* (2009)	0.0083	3.127	6.6-22.6	TL	192	0.980	Izmir Bay
This study	0.0044	3.3561	7.7-17.0	TL	520	0.941	Edremit Bay

same equation is useful for the application of stock assessment models and for the comparison among geographical regions (GONCALVES *et al.*, 1996; MOUTOPOULOS & STERGIOU, 2002; CHERIF *et al.*, 2007). In fact, the analyses of the length-weight relationships given by several authors in the Mediterranean Sea show some differences in *b* values in comparison with Edremit Bay (Table 1). The value b in fish differs according to species, sex, age, seasons and feeding, time of year,

stage of maturity, growth increment or break in growth (BAGENAL &TESCH, 1978; RICKER, 1975; SINOVČIĆ, 2004: FROESE, 2006).

In the present study, spawning occurred between March and October with the peak in July for Edremit Bay population (Fig. 5). Spawning season in Edremit Bay is seen to be different from the relevant studies in Mediterranean Sea (GHARBI & KTARI, 1981b; SANCHEZ *et al*., 1983; N'DA & DENIEL, 1993; REÑONES *et al*., 1995; PAJUELO *et al.,* 1997; ILHAN *et al.,* 2009). Due to different ecological and climate conditions, the start and finish time of reproductive period may happen during different months (NIKOLSKY, 1980).

For a better evidence of the natural life conditions of the striped red mullet in Edremit Bay, seasonal condition has been calculated. According to Fig. 5, maximum condition factor was found in September, being generally higher just prior to spawning season and lower after spawning.

As seen in Fig. 5, the hepatosomatic index shows the highest value in February. The hepatosomatic index is an indicator of feeding activity of fish (TYLER & DUNN, 1976). The hepatosomatic index shows an allocation of energy to the liver during every period except reproduction, when part of the energy is used for gonad maturation (NUNES & HARTZ, 2001). In this study, the values of hepatosomatic index are found to be following a similar trend to values of gonadosomatic index (Fig. 5). This is accordance with the different species studied by HTUN-HUN (1978), DELAHUNTY & DE VLAMING (1980), AVAJI & HANYU (1987), ASAHINA *et al.* (1990), CEK *et al.* (2001), KINGDOM & ALLISON (2011). Since total fish length and weight are included in the calculation of GSI and HSI, they present an auto–corelation (CEK *et al.,* 2001). Besides, the accumulation of heavy metals in fishes affect the hepatosomatic index negatively (SINDHE & KULKAMI, 2004; JOSHI, 2011; NIKAM, 2012). *Mullus* sp. is recommended as indicator species by ANONYMUS (1999). In the comparison to the study in eastern Adriatic Sea (FILIPOVIĆ & RASPOR, 2003), the lower values of hepatosomatic index in Edremit Bay may be probably resulted from the higher accumulation of heavy metals in the striped mullet.

CONCLUSIONS

Edremit Bay, in the northern Aegean Sea, is a place where two currents meet and it is rich in plankton because of upwelling. In addition, the area is fed by waters rich in nutrient from erosion through the Sea of Marmara and the Black Sea. With these facilities, Edremit Bay has a high potential for sea food, especially fish. Since the Bay of Edremit is also known to be a nursery for many species of both pelagic and demersal species (BILECIK, 1989; TOGULGA, 1997), it is important to point out that closure of Edremit Bay for trawl fisheries 18 years ago (ANONYMUS, 1995; CELIK & TORCU, 2000), has positively affected the striped red mullet population.

The fact that purse seine fishery has not been forbidden in Edremit Bay may also lead to the presence of young striped mullets in the catch, which are chosen as target species (CEYHAN *et al.,* 2006).

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Neki biološki parametri trlje kamenjarke (*Mullus surmuletus* L.) iz Erdemitskog zaljeva, (Sjeverno Egejsko more, Turska)

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SAŽETAK

Starost, rast i smrtnost trlje kamenjarke, (*Mullus surmuletus* L.) procijenjene su kod 520 jedinki prikupljenih na sjeverozapadnoj obali Egejskog mora, Erdemitski zaljev u Turskoj od rujna 2009. do srpnja 2010. Ukupna duljina jedinki je u rasponu od 7,7 do 17,0 cm, a masa je kolebala između 3,50 i 58,9 g. Prema dužinsko-težinskom odnosu, ustanovljena je pozitivna alometrija za oba spola. Omjer zastupljenosti spolova bio je u korist mužjaka (1: 1,73). Mjesečne vrijednosti gonadosomatskog indeksa (GSI) za ženke pokazuju da se mrijest obavlja posebice u razdoblju travanj - rujan, sa vrhuncem u srpnju. Vrijednosti kondicijskog faktora (CF) i hepatosomatskog indeksa (HSI) kolebali su između 0.71-1.57 i 0.10-1.43, respektivno.

Ključne riječi: *Mullus surmuletus*, Erdemitski zaljev, dužinsko-maseni odnos, omjer spolova, gonadosomatski indeks